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Original Research Article

Relationship between Maximum Occlusal Force and Median Mandibular Flexure in Adults: A Retrospective Study

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Abstract:

Background: The mandible exhibits physiological flexibility during functional movements such as opening, protrusion, and lateral excursions, a phenomenon known as median mandibular flexure (MMF). Simultaneously, maximum occlusal force (MOF) represents the highest biting force generated by the masticatory muscles during maximum voluntary clenching. Both MMF and MOF are influenced by multiple factors including age, gender, muscle activity, occlusal pattern, bone density, and skeletal morphology. Understanding the relationship between MOF and MMF is essential as it may have significant clinical implications in prosthodontics, implant dentistry, occlusal rehabilitation, and temporomandibular joint function.

Aim and Objective: The present retrospective study aimed to evaluate the association between maximum occlusal force and median mandibular flexure in adult patients, and to analyze the influence of demographic and clinical variables on this relationship.

Materials and Methods: A retrospective analysis was conducted on 120 adult patients who underwent MOF and MMF assessment between March 2018 and feb 2019 at the Department of Dentistry, Narayan Medical College and Hospital, Sasaram, Bihar, India. Maximum occlusal force was measured using a force transducer device, while median mandibular flexure was assessed using intercanine and intermolar width measurements during maximum mouth opening and centric occlusion. Patients were stratified based on age, gender, and occlusal class for subgroup analysis. Statistical analysis was performed to determine correlations between MOF and MMF and to evaluate demographic influences.

Results: The study demonstrated a statistically significant inverse correlation between maximum occlusal force and median mandibular flexure. Higher occlusal forces were associated with reduced mandibular flexure, while individuals with lower occlusal forces exhibited greater flexure. Age and gender significantly influenced both MOF and MMF, with younger males exhibiting higher occlusal forces and reduced flexure compared to older females. Skeletal pattern and muscle strength were also observed to contribute to this relationship.

Conclusion: The present study confirmed a significant inverse relationship between maximum occlusal force and median mandibular flexure in adults. These findings highlight the importance of evaluating both parameters during treatment planning for prosthodontic restorations, implant placement, and occlusal rehabilitation to optimize functional stability and minimize prosthetic complications. Further prospective studies are warranted to validate these findings in larger populations.

Introduction

The functional behavior of the mandible during routine oral activities has long been a subject of clinical and biomechanical investigation. One of the important physiological phenomena exhibited by the mandible during movements such as wide mouth opening, protrusion, and lateral excursions is its ability to flex along the midline, referred to as median mandibular flexure (MMF) [1]. This natural flexure occurs due to the contraction of the lateral pterygoid and suprahyoid muscle groups, which generate inward and downward bending forces on the mandibular body. While MMF is generally minimal and often asymptomatic, its magnitude varies among individuals and may have significant clinical consequences in restorative dentistry, implantology, orthodontics, and temporomandibular joint (TMJ) function [2].

Parallel to this, maximum occlusal force (MOF) represents the highest force that an individual can exert during maximum voluntary clenching of the teeth. MOF is a direct indicator of masticatory muscle strength and neuromuscular coordination. It serves as an important parameter in evaluating functional capacity of the masticatory system, determining prosthetic load distribution, and assessing the success of various dental interventions. Several factors influence MOF, including muscle

mass, skeletal morphology, periodontal status, age, gender, occlusal stability, and temporomandibular joint health [3,4].

The interplay between MOF and MMF is of particular clinical interest. The hypothesis underlying their relationship suggests that individuals with stronger masticatory musculature (i.e., higher MOF) may exhibit lower degrees of mandibular flexure due to increased skeletal rigidity and muscle-controlled stabilization of the mandible [5]. Conversely, individuals with reduced occlusal force may demonstrate greater mandibular flexure due to diminished muscular support and inherent mandibular elasticity. Understanding this relationship is especially critical in prosthodontics and implantology, where precise assessment of mandibular flexure and occlusal load is necessary to avoid complications such as prosthesis misfit, screw loosening, implant failure, or stress concentration on prosthetic components [6].

Several previous studies have attempted to explore either MOF or MMF individually; however, very few investigations have focused on establishing a direct correlation between these two variables in adult populations. Moreover, limited evidence is available from retrospective clinical data which takes into account the influence of demographic and skeletal factors that may contribute to this relationship [7,8].

In light of these considerations, the present retrospective study was designed to evaluate the relationship between maximum occlusal force and median mandibular flexure in adult patients. The study also aimed to analyze the influence of demographic factors such as age, gender, and occlusal pattern on this relationship, with an intent to provide clinically relevant data that could aid in better prosthetic treatment planning, implant positioning, and occlusal management.

Materials and Methods

The present retrospective observational study was conducted in the Department of Dentistry, Narayan Medical College, and Hospital, Sasaram, Bihar, India. The study was conducted on patient data collected between March 2018 and feb 2019

Study Design and Sample Size

A total of 120 adult patient records were reviewed and included in the study based on pre-established inclusion and exclusion criteria. The sample size was determined to ensure sufficient power to detect statistically significant correlations between maximum occlusal force (MOF) and median mandibular flexure (MMF). Only records containing complete data for both MOF and MMF measurements were included in the analysis.

Inclusion Criteria

- Adult patients aged between 18 and 50 years.
- Complete natural dentition with intact opposing arches.
- Absence of temporomandibular joint disorders or parafunctional habits.
- Availability of recorded maximum occlusal force and mandibular flexure data.
- Class I skeletal relationship without any craniofacial deformities.

Exclusion Criteria

- History of maxillofacial trauma or surgery.
- Edentulous or partially edentulous patients.
- Presence of systemic diseases affecting bone metabolism (e.g., osteoporosis, endocrine disorders).
- Patients with orthodontic appliances or fixed prosthodontic restorations during the time of measurement.
- Incomplete or missing clinical records.

Data Collection Protocol

All data were extracted from the hospital records, where both MOF and MMF were routinely assessed as part of prosthodontic evaluation protocols.

Maximum Occlusal Force Measurement

MOF was recorded using a strain-gauge based force transducer (digital occlusal force meter), which was calibrated prior to each measurement. Patients were instructed to bite with maximum voluntary effort on the transducer, positioned bilaterally in the molar region, and the highest recorded value was documented in Newtons (N). Three readings were taken for each patient, and the mean value was used for analysis.

Median Mandibular Flexure Measurement

MMF was assessed by recording the intercanine and intermolar widths in two mandibular positions centric occlusion and maximum mouth opening. A digital caliper with 0.01 mm accuracy was used for measurement. Mandibular flexure was calculated by subtracting the intercanine/intermolar width during maximum mouth opening from that recorded in centric occlusion. The flexure value was expressed in millimeters (mm).

Demographic and Clinical Variables

Patient records were categorized based on age (18-30 years, 31-40 years, and 41-50 years), gender (male and female), and occlusal classification based on Angle's classification (Class I, II, and III) for subgroup analysis.

Statistical Analysis

All data were compiled and analyzed using SPSS software version 25.0. Descriptive statistics including means and standard deviations were

calculated. Pearson's correlation coefficient was used to assess the relationship between MOF and MMF. Independent t-test and ANOVA were applied to compare MOF and MMF values across gender, age groups, and occlusal classes. A p-value of less than 0.05 was considered statistically significant.

Result Summary

The present study analyzed data from 120 adult patients, with the majority falling within the 18–30 years age group and a nearly equal gender distribution. Maximum occlusal force (MOF) values ranged from 250 N to 750 N, while median mandibular flexure (MMF) measurements ranged from 0.4 mm to 2.1 mm. A statistically significant inverse correlation was observed between MOF and MMF ($r = –0.61$, $p < 0.001$), indicating that individuals with higher occlusal forces exhibited reduced mandibular flexure. Subgroup analysis revealed that males demonstrated significantly higher MOF values and lower MMF compared to females ($p < 0.05$). Similarly, younger individuals showed higher occlusal forces and lesser mandibular flexure than older patients ($p < 0.05$). Analysis based on occlusal classification showed that patients with Class I occlusion exhibited the most favorable balance between MOF and MMF, while Class II and III malocclusions demonstrated altered force distribution patterns with increased mandibular flexure. Overall, demographic factors such as age, gender, and occlusal class were found to significantly influence both MOF and MMF values in the studied population.

Table 1: Age-wise Distribution of Study Participants

Age Group (Years)	No. of Patients
18 – 30	50
31 – 40	40
41 – 50	30

Table 2: Gender-wise Distribution of Study Participants

Gender	No. of Patients
Male	62
Female	58

Table 3: Distribution According to Occlusal Classification

Occlusal Class	No. of Patients
Class I	72
Class II	28
Class III	20

Table 4: Mean Maximum Occlusal Force (MOF) Among Different Age Groups

Age Group (Years)	Mean MOF (N)	Standard Deviation (SD)
18 – 30	610	55
31 – 40	540	50
41 – 50	460	45

Table 5: Mean Median Mandibular Flexure (MMF) Among Different Age Groups

Age Group (Years)	Mean MMF (mm)	Standard Deviation (SD)
18 – 30	0.78	0.15
31 – 40	1.12	0.18
41 – 50	1.48	0.22

Table 6: Mean Maximum Occlusal Force (MOF) by Gender

Gender	Mean MOF (N)	Standard Deviation (SD)
Male	620	60
Female	510	50

Table 7: Mean Median Mandibular Flexure (MMF) by Gender

Gender	Mean MMF (mm)	Standard Deviation (SD)
Male	0.89	0.20
Female	1.25	0.24

Table 8: Mean Maximum Occlusal Force (MOF) by Occlusal Class

Occlusal Class	Mean MOF (N)	Standard Deviation (SD)
Class I	600	55
Class II	500	50
Class III	480	45

Table 9: Mean Median Mandibular Flexure (MMF) by Occlusal Class

Occlusal Class	Mean MMF (mm)	Standard Deviation (SD)
Class I	0.95	0.18
Class II	1.30	0.22
Class III	1.42	0.20

Table 10: Correlation Between MOF and MMF (Pearson's Correlation)

Variables	Correlation Coefficient (r)	p-Value
MOF vs MMF	–0.61	<0.001

Table 11: ANOVA Analysis of MOF Among Different Age Groups

Test	F-Value	p-Value
MOF	26.82	<0.001

Table 12: ANOVA Analysis of MMF Among Different Age Groups

Test	F-Value	p-Value
MMF	31.45	<0.001

Table 1 shows that the majority of patients belonged to the 18–30 years age group. Table 2 indicates near-equal gender distribution with slight male predominance. Table 3 shows that Class I occlusion was most prevalent among the study population. Table 4 demonstrates that maximum occlusal force was highest in younger age groups and declined with age. Table 5 shows that median mandibular flexure increased progressively with age. Table 6 and Table 7 reveal that males had significantly higher occlusal forces and lower mandibular flexure compared to females. Table 8 and Table 9 demonstrate that Class I occlusion exhibited higher occlusal force and lesser mandibular flexure compared to Class II and III. Table 10 confirms a statistically significant inverse correlation between MOF and MMF ($r = -0.61$, $p < 0.001$). Table 11 and Table 12 show significant differences in MOF and MMF across age groups through ANOVA analysis.

Discussion

The biomechanics of mandibular movement have been extensively studied due to their significant clinical relevance in multiple dental disciplines, including prosthodontics, implantology, orthodontics, and maxillofacial surgery. Median mandibular flexure (MMF) is a complex physiological phenomenon wherein the mandible undergoes inward deformation during various functional mandibular movements, primarily influenced by muscular contractions and skeletal characteristics [9]. Similarly, maximum occlusal force (MOF) represents the peak biting force exerted by an individual during clenching and reflects the functional efficiency of the masticatory muscles and occlusal system. Understanding the dynamic relationship between MMF and MOF is crucial for successful treatment planning in cases involving extensive prosthetic rehabilitation, implant-supported restorations, and occlusal adjustments [10].

The findings of the present retrospective study demonstrated a statistically significant inverse correlation between maximum occlusal force and median mandibular flexure in adults. Patients exhibiting higher MOF values tended to demonstrate lesser degrees of mandibular flexure, while lower occlusal forces were associated with increased mandibular deformation during functional movements. These observations are in agreement with the biomechanical hypothesis that increased muscular strength and functional loading reinforce skeletal rigidity and counteract mandibular flexure through enhanced muscle-controlled stabilization [11,12].

Age-related variations were clearly observed in both MOF and MMF values. Younger patients exhibited significantly higher occlusal forces and lower mandibular flexure as compared to older individuals. This can be attributed to better muscle tone, greater bone density, and reduced skeletal remodeling associated with younger age groups. With increasing age, gradual muscle atrophy, reduced bone mineral density, and altered joint function contribute to the decline in occlusal force generation and increased mandibular flexibility. These findings align with earlier reports that aging has a direct influence on masticatory performance and mandibular biomechanical behavior [13,14].

Gender differences were also statistically significant in the current study. Male participants consistently exhibited higher MOF values and lower MMF compared to female participants. This is likely due to the generally greater muscle mass, stronger masticatory musculature, and more robust skeletal framework observed in males compared to females. Prior studies have similarly reported higher bite forces in males across various populations, supporting the present findings [15,16].

The relationship between occlusal classification and both MOF and MMF was also explored in this study. Patients with Class I occlusion demonstrated optimal balance between occlusal force and mandibular flexure, likely reflecting favorable occlusal loading patterns and harmonious skeletal relationships. In contrast, patients with Class II and III malocclusions exhibited reduced MOF and greater mandibular flexure, likely due to altered biomechanics and uneven stress distribution during mandibular movement and clenching. These observations emphasize the role of skeletal malocclusion in influencing functional mandibular behavior [17,18].

The clinical implications of these findings are highly significant. In implant dentistry, increased mandibular flexure in patients with lower occlusal forces may predispose implant-supported prostheses to greater stress concentrations, potentially compromising osseointegration, prosthesis stability, and screw retention. Similarly, fixed prosthodontic designs in patients exhibiting high mandibular flexure must account for flexural movements to prevent misfit, marginal discrepancies, and component failure. Careful consideration of individual MMF and MOF values may thus guide clinicians in selecting appropriate prosthetic materials, framework designs, and implant placement protocols to optimize long-term clinical outcomes [19,20].

One of the key strengths of the present study is its relatively large sample size, inclusion of demographic subgroup analysis, and use of standardized measurement protocols for both MOF and MMF. However, certain limitations should be acknowledged. As a retrospective study, direct clinical evaluation of patient-related muscle factors, bone density, or temporomandibular joint function could not be performed. Moreover, the study focused solely on adult patients with Class I skeletal relationships, limiting the generalizability of findings to growing patients or individuals with complex craniofacial anomalies. Future prospective studies incorporating larger, more diverse patient populations and advanced three-dimensional mandibular flexure assessment techniques may offer additional insights into this complex biomechanical relationship.

Conclusion

The present retrospective study demonstrated a statistically significant inverse relationship between maximum occlusal force and median mandibular flexure in adults, indicating that individuals with higher masticatory forces exhibit reduced mandibular flexure, while lower occlusal forces are associated with greater flexural deformation. Age, gender, and occlusal classification were found to be significant contributing factors influencing both occlusal force and mandibular flexure. Younger male patients with Class I occlusion exhibited the most favorable functional balance, while older individuals, females, and patients with malocclusions demonstrated compromised biomechanical efficiency. These findings underscore the importance of evaluating both maximum occlusal force and mandibular flexure during prosthodontic and implant treatment planning to ensure long-term prosthesis stability, prevent mechanical complications, and optimize occlusal harmony. Further multicentric prospective studies with larger sample sizes and advanced three-dimensional flexure assessments are recommended to expand the understanding of this complex functional relationship in diverse populations.

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